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RELATIVE TRANSPIRATION OF OLD AND NEW LEAVES OF THE MYRTUS TYPE.

JOSEPH Y. BERGEN.

WHILE making some studies of the transpiration of the coriaceous-leaved evergreens of the Neapolitan region, such as *Olea*, *Pistacia*, and *Quercus Ilex*, the writer became interested in the question of the relative activity in transpiration of their old and new leaves. Some results of the measurements made upon them are here set down, together with a few words of discussion in regard to the meaning of the facts observed.

It is commonly said that the trees and shrubs of the Mediterranean region are largely evergreen, but a little examination into their characteristics shows that the word "evergreen" should be used to describe them only when its meaning is carefully defined. When local floras, like GUSSONE's excellent catalogue of the plants of Ischia, describe such summer deciduous shrubs as *Spartium junceum*, *Cytisus scoparius*, and *Calycotome villosa* as evergreens, it would seem that any woody plant with leaves which remain green during a considerable part of the winter is considered to be an evergreen. As a matter of fact, the angiospermous trees and shrubs of the coastwise region about Naples seem to be classifiable, as regards their mode of shedding the leaves, into the divisions shown in the table[1] on the opposite page.

Some of the plants of division I may be described as facultative deciduous species; that is, they may retain their leaves almost or quite the year around. The Medicago and the Euphorbia above named do this when the water supply is abundant.

The members of division II are more or less covered with leaves at all seasons. Those which belong to subdivision 1 show little difference in density of foliage dependent on the season. Many, however, of subdivision 2 lose nearly all their old leaves soon after the new leaves have reached their full size (area). *Rhamnus Alater-*

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[1] The table given is merely illustrative and does not embrace nearly all the species which the writer has observed.

I. Leaves simultaneously deciduous	1. Winter deciduous	*Juglans*, *Populus*, *Fagus*, *Castanea*, *Quercus* (in part), *Ulmus*, *Morus*, *Ficus*, *Vitis*, etc.
	2. Summer deciduous	*Calycotome villosa* *Coronilla Emerus* *Spartium junceum* *Medicago arborescens* *Euphorbia dendroides*
I. Leaves not simultaneously deciduous (evergreen)	1. Leave some of them lasting two years or more	*Olea europaea* *Pistacia Lentiscus*
	2. Leaves lasting more than one year but less than two	*Rhamnus Alaternus*[2] *Nerium Oleander*[2] *Quercus Ilex*[3] *Ceratonia Siliqua*[3] *Arbutus Unedo*[3]

nus and *Nerium Oleander* are therefore much less leafy by July 1 than they were throughout May.

A large proportion of the time spent was devoted to leaves of the so-called Myrtus type; those namely of *Olea europaea*, *Quercus Ilex*, *Rhamnus Alaternus*, and *Nerium Oleander*.

Four other species, namely, *Pistacia Lentiscus*, *Hedera Helix*, *Smilax aspera*, and *Viburnum Tinus*, were also studied, in order to give any conclusions that were reached a more general value, as applicable to the sclerophyll trees and shrubs of the region.

With every species, some comparisons of the relative rate of transpiration for old and new leaves were made as soon as the latter had reached their full areal growth.

RELATIVE THICKNESS OF OLD AND NEW LEAVES.

On comparing the thickness of the old leaves with that of new ones of the same species which had just reached their full area (usually in May) the older ones were commonly found to be somewhat thicker. All of the species in the list above given were examined except Viburnum, and the average ratio for all seven species was $\frac{\text{thickness old leaf}}{\text{thickness new leaf}} = 1.2$. The greatest disparity was found in Pistacia, which sometimes gave a ratio of 1.48, and the least was in Hedera, which frequently showed no difference in the respective thicknesses. The greater thickness of the old leaves was not mainly due to growth of the

[2] These last fifteen months or but little more. [3] These last eighteen months or more.

epidermis; the amount due to this cause was never found to be more than 10 per cent. of the whole difference in thickness, and sometimes the epidermis of the new leaf was as thick as that of the old one. All the measurements were carefully made with the eyepiece micrometer.

RELATIVE TRANSPIRATION OF OLD AND NEW LEAVES.

The measurements of transpiration were all made by determination of loss of weight of twigs in water, except in the case of Nerium of which leaves only were used, with the petioles immersed. The time allowed was usually one hour, and the temperature (always the same for each comparison) ranged on different days from 25 to 31° C. Observations were begun on May 8 and continued at intervals until August 6.

In the following table are given the ratios of rates of transpiration for equal areas of old leaves and new ones which had just attained their maximum area. The values given are usually averages of several observations taken daily or at intervals of two or three days during a period of a week or ten days. The column $o \div n$ represents the ratio, *amount of transpiration per hour for* $100^{\mathrm{sq\,cm}}$ *of old leaves divided by the corresponding amount for new leaves.*

TRANSPIRATION RATIOS; EQUAL AREAS.

	$o \div n$
Olea europaea	1.05
Quercus Ilex	3.53
Rhamnus Alaternus	0.78
Nerium Oleander	2.45
Pistacia Lentiscus	1.08
Hedera Helix	0.18
Smilax aspera	2.16
Viburnum Tinus	2.10

It is obvious at a glance that in general the new leaves have not attained their full power of transpiration when they have reached the area of maturity. This fact is not wholly a result of the imperfect development in thickness already mentioned, for when the transpiration ratios are referred, not to equal areas of leaves, but to equal weights, the older leaves often maintain their position as the more active, as is sufficiently shown by the following values. These results cannot be closely compared with those of the preceding table, since the former contains averages based on a larger number of determinations for each species.

TRANSPIRATION RATIOS; EQUAL WEIGHTS.

	o ÷ n
Quercus Ilex	2.73
Smilax aspera	2.32
Viburnum Tinus	1.74

In two species, the Rhamnus and the Hedera, the old leaves are seen to be notably deficient in capacity for transpiration. In the former this fact is very possibly due to the moribund condition of the old leaves, which at the time of observation were about to turn yellow and fall. In the latter, the leaves were not ready to fall, and some other explanation of their sluggish action needs to be sought.

In view of the marked differences in transpiration between the old and the new leaves of most of the species studied, it seemed worth while to investigate the question whether these differences were accentuated or diminished by covering the stomatal surface (the lower one) with wax and so comparing the normal transpiration with the epidermal taken alone. This inquiry was not undertaken until so late in the season that only a portion of the comparisons which it would have been desirable to make were possible. The most convenient way of expressing the results seemed to be to give the ratio, *loss of water by plain leaf divided by loss of water by waxed leaf*, first for the old leaves, then for the new ones, of each species examined.

TRANSPIRATION RATIOS; PLAIN AND WAXED LEAVES

	PLAIN ÷ WAXED	
	Old leaves	New leaves
Olea europaea	2.62	3.17
Nerium Oleander	3.52	12.75
Pistacia Lentiscus	3.00	5.33
Hedera Helix	2.93	6.80

In the species examined it is evident that the total transpiration exceeds the epidermal alone much more in the new leaves than the old ones. Examination of the actual amounts of moisture lost in each case leads me to suppose that this inequality is due to the greater impermeability of young epidermis (several months old) than of that which is more than a year old, and to the greater functional activity of the younger than of the older stomata. One would *a priori* have expected to find the thicker and more indurated epidermis of the older leaves more impermeable than that of the younger ones, but in many cases it certainly is not. For instance, the older leaves of Nerium were found to lose moisture more than five times as fast for equal areas as the younger ones (both with the lower surface waxed), and the older leaves of Olea lost moisture nearly four times as fast as the younger ones (both waxed below).

In the table above given the losses from waxed leaves may be a little too high relatively to the losses from plain leaves, since the former values were obtained after the leaves had been standing in water longer, and therefore, perhaps may have established a better transpiration current. But this would not affect the general conclusions to be derived from the data.

The leaves of Olea and of Pistacia compared in the last table were aged about six months ("young") and eighteen months ("old") respectively, and those of Nerium and Hedera were about three and a half and fifteen and a half months of age.

None of the results obtained by the writer in transpiration experiments upon sclerophyll leaves can be much elucidated by comparison with the conclusions (contradictory among themselves) obtained in the studies of young and old leaves by SCHIRMER, KRUTITZKY, TSCHAPLOWITZ, HÖHNEL, and others,[4] since none of these authors dealt with leaves which differed in age by an entire year. It is also unlikely that sclerophyll leaves should in their behavior as regards transpiration closely resemble the leaves of the herbaceous Gramineae, those of Coleus, Phaseolus, Pisum, and such other species as have received most study with reference to the relation between their development and their power of transpiration.

CONCLUSIONS.

The conclusions of the present paper may be summarized as follows:

1. The evergreen trees and shrubs of the Neapolitan region differ greatly in the longevity of their leaves, some of the species having

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[4] Summarized by BURGENSTEIN, Materialien zu einer Monographie betreffend die Erscheinungen der Transpiration der Pflanzen. II Theil, pp. 25, 26. Wien. 1889. A. Hölder.

leaves that live only about fifteen months, while those of others live more than two and a half years.

2. All of the leaves studied reach their maximum area considerably before they attain their full thickness.

3. The leaves of six out of the eight species studied transpire more for equal areas when fifteen to eighteen months old than they do when they have just reached their maximum area (*i. e.*, at three or four months).

4. Transpiration for equal weights of leaves is generally more active for leaves of fifteen or more months than for those of three months or a little older.

5. Epidermal transpiration bears a much smaller ratio to total transpiration in leaves of three months than in those of fifteen months.

NAPLES, ITALY.